U.S. Naval Observatory VLBI Analysis Center

David A. Boboltz, Alan L. Fey, Nicole Geiger, Roopesh Ojha, Zachary Dugan, Kerry A. Kingham, David M. Hall

Abstract

This report summarizes the activities of the VLBI Analysis Center at the United States Naval Observatory for calendar year 2009. Over the course of the year, Analysis Center personnel continued analysis and timely submission of IVS-R4 databases for distribution to the IVS. During the 2009 calendar year, the USNO VLBI Analysis Center answered a call for contributions to ITRF2008 and produced two periodic global Terrestrial Reference Frame (TRF) solutions for internal use only. Earth orientation parameters (EOP), updated by the latest diurnal (IVS-R1 and IVS-R4) experiments, were routinely submitted to the IVS. Sinex files based upon the bi-weekly 24-hr experiments were also submitted to the IVS, and in 2009, the Analysis Center began production of a Sinex series based upon the 1-hr Intensives.

Other activities in the 2009 calendar year included continued research into celestial reference frames. Analysis Center personnel made significant contributions to the recently approved Second Realization of the ICRF (ICRF2) and continued research into future high-frequency reference frames based upon the VLBA K/Q-band experiments. VLBI Analysis Center personnel also implemented the DiFX software correlator at USNO and were involved in its testing and evaluation. Finally, a program of observations using the Very Long Baseline Array (VLBA) were initiated to test the feasibility of using the VLBA to measure UT1-UTC.

1. Introduction

The USNO VLBI Analysis Center is supported and operated by the United States Naval Observatory (USNO) in Washington, DC. The primary services provided by the Analysis Center are the analysis of diurnal experiments, the production of periodic global Terrestrial Reference Frame (TRF) and Celestial Reference Frame (CRF) solutions, and the submission to the IVS of Intensive (EOP-I) and session-based (EOP-S) Earth orientation parameters based on USNO global TRF solutions. Analysis Center personnel maintain the necessary software required to continue these services to the IVS including periodic updates of the GSFC CALC/SOLVE software package. In addition to operational VLBI analysis, Analysis Center personnel are actively engaged in research related to future reference frames, e-VLBI, and software correlation.

2. Current Analysis Center Activities

2.1. IVS Experiment Analysis and Database Submission

During the 2009 calendar year, personnel at the USNO VLBI Analysis Center continued to be responsible for the timely analysis of the IVS-R4 experiments, with the resulting databases to be submitted within 24 hours of correlation for dissemination by the IVS. Due to a decrease in staffing, the Analysis Center temporarily suspended in-house analysis of the IVS-R1 experiments in favor of using the databases submitted by NASA GSFC. Analysis Center personnel continue to be responsible for the analysis and database submission for the periodic IVS-CRF experiments. The primary goal of these experiments is the densification of ICRF sources in the southern hemisphere. In 2009, USNO scheduled and analyzed four CRF related experiments including IVS-CRF55 through IVS-CRF57, and IVS-CRFS13. The analyzed databases were submitted to the IVS. Analysis Center

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2009		**00-00-2009 to 00-00-2009**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
U.S. Naval Observatory VLBI Analysis Center	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Naval Observatory,3450 Massachusetts Avenue, N.W.,Washington,DC,20392**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This report summarizes the activities of the VLBI Analysis Center at the United States Naval Observatory for calendar year 2009. Over the course of the year, Analysis Center personnel continued analysis and timely submission of IVS-R4 databases for distribution to the IVS. During the 2009 calendar year, the USNO VLBI Analysis Center answered a call for contributions to ITRF2008 and produced two periodic global Terrestrial Reference Frame (TRF) solutions for internal use only. Earth orientation parameters (EOP), updated by the latest diurnal (IVS-R1 and IVS-R4) eperiments, were rountinely submitted to the IVS. Sinex files based upon the bi-weekly 24-hr experiments were also submitted to the IVS, and in 2009, the Analysis Center began produciton of a Sinex series based upon the 1-hr intensives.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

personnel also continued analyzing IVS Intensive experiments for use in the USN-EOPI time series.

2.2. Global TRF Solutions, EOP and Sinex Submission

During 2009, Analysis Center personnel answered an IVS call for contributions to ITRF2008 by producing a series of Sinex files based on the entire USNO data set dating back to 1979. This series departed from the typical USNO Sinex distribution by making use of the Vienna Mapping Function (VMF) for tropospheric delay determination. The Sinex series was submitted to the IVS Analysis Coordinator for use in ITRF2008.

USNO VLBI Analysis Center personnel continued to produce periodic global EOP/TRF solutions (usn2009a and usn2009b) over the course of the 2009 calendar year. However, these solutions were produced for internal use only, and they were not submitted to the IVS. Analysis Center personnel continued to submit the USN-EOPS series based on the global TRF solutions updated with new IVS-R1/R4 experiments. The updated EOPS series was submitted to the IVS twice weekly within 24 hours of experiment correlation and is included in the IERS Bulletin A. Analysis Center personnel also continued routine submission of Sinex format files based upon the 24-hr VLBI sessions. In addition to EOPS and Sinex series, USNO VLBI Analysis Center personnel continued to produce and submit an EOPI series based upon the IVS intensive experiments.

2.3. Celestial Reference Frame (CRF)

During the 2009 calendar year, Analysis Center personnel primarily focused on the completion of the Second Realization of the International Celestial Reference Frame (ICRF2) for approval by the International Astronomical Union (IAU). In preparation for ICRF2, Analysis Center personnel produced multiple CRF solutions, performed time series analysis of source position variations for the purpose of source classification, and investigated the feasibility of adding the VLBA Calibrator Survey sources to the CRF. On 13 August 2009, Resolution B3 adopting the ICRF2 as the fundamental celestial reference frame as of 1 January 2010 was approved by the XXVII IAU General Assembly. ICRF2 includes a total of 3414 extragalactic sources of which 295 were selected as "defining" sources. The sky distribution of the ICRF2 Defining sources is shown in Figure 1. USNO VLBI Analysis Center personnel made significant contributions to the IERS Technical Note No. 35, which provides a complete description of ICRF2 and is available at the following Web site:

`http://www.iers.org/MainDisp.csl?pid=46-1100252.`

In 2009, Analysis Center personnel continued to collaborate with colleagues from Bordeaux Observatory, NASA GSFC, NASA HQ, NASA JPL, and NRAO on a program of high-frequency reference frame observations made with the VLBA. This project aims to investigate the feasibility of a CRF at frequencies between 24 and 43 GHz. Two sessions were observed in 2009 (BL151a and BL151b) bringing the total to 12. Four additional epochs were approved for observation in 2009-2010 (BL166). Results from the program are presented in two upcoming articles (Lanyi et al. 2010, AJ, in press; Charlot et al. 2010, AJ, in press).

2.4. Software Correlator

Over the course of the 2009 calendar year, Analysis Center personnel began implementation, testing and evaluation of the DiFX software correlator. USNO currently has a small cluster of five multi-core machines on which the software correlator is implemented. Analysis Center personnel

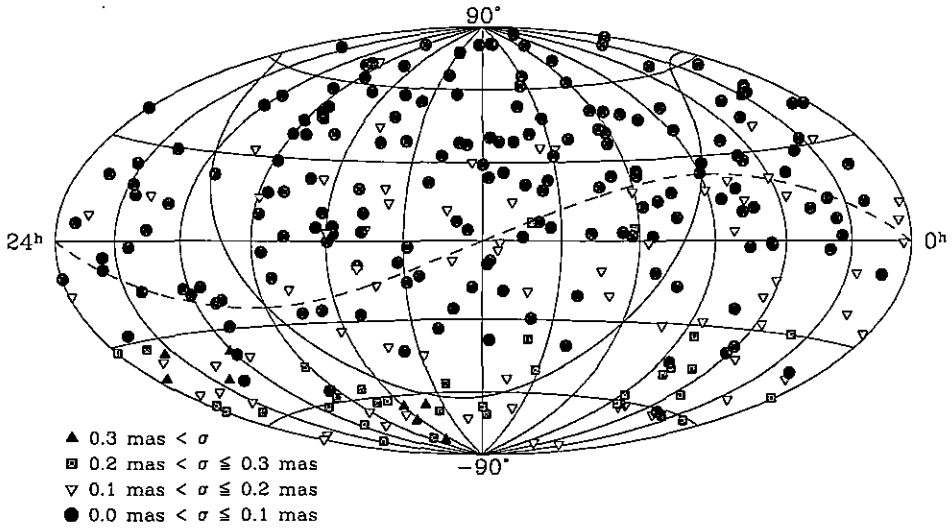

Figure 1. The distribution of the 295 ICRF2 Defining sources on an Aitoff equal area projection of the celestial sphere.

have been interfacing with colleagues at various institutions and attended a DiFX meeting in Perth, Australia in October of 2009. Post-correlation calibration is currently being performed within the Astronomical Image Processing System (AIPS), and the database production and analysis is performed within CALC/SOLVE.

2.5. VLBA EOP Experiments

During the 2009 calendar year, Analysis Center personnel began a program to test the feasibility of using the Very Long Baseline Array (VLBA) operated by the National Radio Astronomy Observatory (NRAO) for the purpose of measuring UT1-UTC. A secondary goal of the observations was to test the implementation of the DiFX software correlator at USNO. In Feb. 2009, a series of test observations (TC015) were begun. These observations consisted of five antennas of the VLBA and were scheduled in a geodetic mode optimized for the Mauna Kea to St. Croix baseline with the remaining three antennas (Hancock, Los Alamos, and Pie Town) as tag-along stations. All of the data from the experiments were correlated on the software correlator and compared to results from the NRAO hardware correlator. The data were further analyzed within CALC/SOLVE, and EOPI results compared to other USNO EOP series. Figure 2 shows differences between IERS-C04-05 and the TC015 results. The panel on the left shows the results for just the MK-SC baseline, while the right panel shows the results for all 5 stations combined. Differences between IERS C04-05 and the USN-EOPI and USN-EOPS series are also shown. The TC015 series continued through the end of 2009 and will continue at monthly intervals through mid-2010 in order to cover a full Chandler cycle. An additional series (TB014) was recently approved for observation by the VLBA

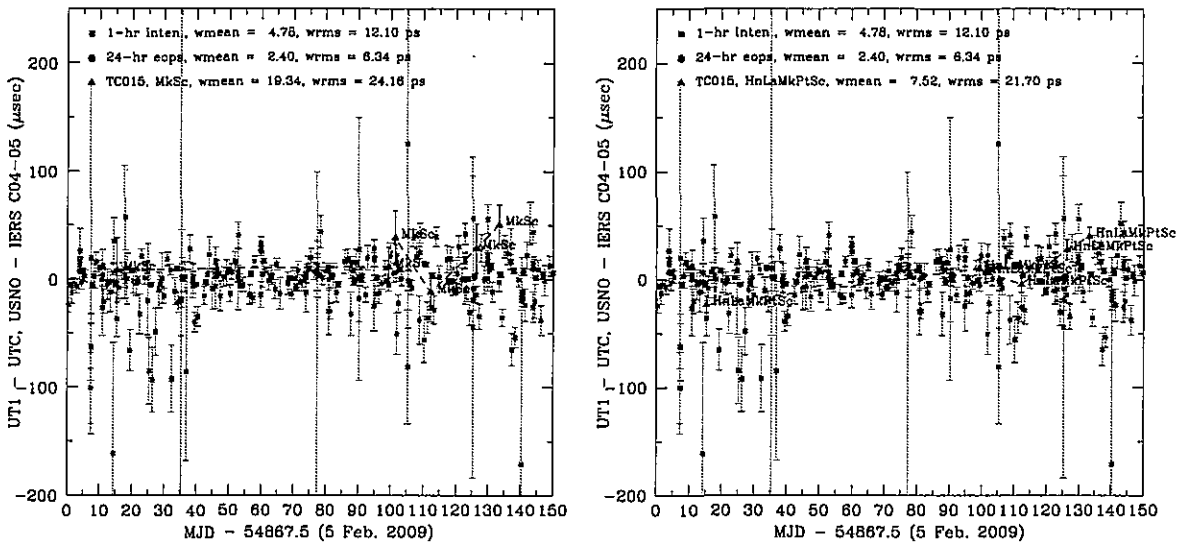

Figure 2. Differences in UT1-UTC between IERS C04-05 and data from VLBA experiment TC015. The left panel shows results for the primary baseline MK-SC. The right panel shows results for all five stations combined. Also shown in each panel are differences between IERS C04-05 and both the USN-EOPI and USN-EOPS standard series for comparison.

in 2010. This series will include only three stations—Mauna Kea, Los Alamos, and Pie Town—and will test the effects of shorter baselines on UT1-UTC.

3. Staff

The staff of the VLBI Analysis Center is drawn from individuals in both the Astrometry and Earth Orientation departments at the U.S. Naval Observatory. The staff and their responsibilities are as follows:

Name	Responsibilities
David Boboltz	Periodic global TRF solutions and comparisons, Sinex generation and submission, Web page administration, VLBI data analysis.
Alan Fey	Periodic global CRF solutions and comparisons, CRF densification research, Web page administration, VLBI data analysis.
Nicole Geiger	VLBI data analysis, EOP and database submission.
Roopesh Ojha	Software correlator implementation, VLBA scheduling and data analysis.
Zachary Dugan	VLBI data analysis, EOP and database submission.
Kerry Kingham	Correlator interface, VLBI data analysis.
David Hall	Correlator interface, VLBI data analysis.